

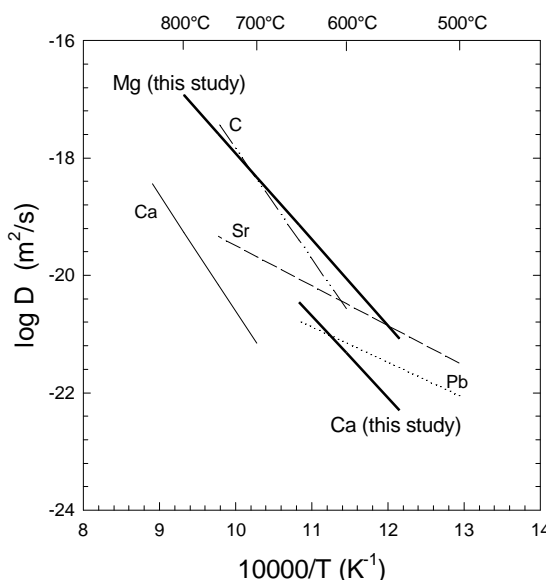
RESEARCH HIGHLIGHT
Office of Basic Energy Sciences
Geosciences Program

Project: Cation Diffusion Rates in Selected Minerals

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Objective: Determine experimental cation diffusion coefficients for carbonate minerals at temperatures less than 1000°C for evaluating disequilibrium behavior in geological, nuclear waste, energy, and materials concerns.

Results: The self-diffusion of Ca and the tracer diffusion of Mg in calcite have been experimentally measured using isotopic tracers of ^{25}Mg and ^{44}Ca . Natural single crystals of calcite were coated with a thermally-sputtered oxide thin film and then annealed in a CO_2 gas at one atmosphere total pressure and temperatures from 550 to 800°C. Diffusion coefficient values were derived from the depth profiles obtained by ion microprobe analysis. The resultant activation energies for Mg tracer diffusion and Ca self-diffusion are respectively: $E_a(\text{Mg}) = 284 \pm 74 \text{ kJ/mol}$ and $E_a(\text{Ca}) = 271 \pm 80 \text{ kJ/mol}$. For the temperature ranges in these experiments, the diffusion of Mg is faster than Ca. The results are generally consistent in magnitude with divalent cation diffusion rates obtained in previous studies and provide a means of interpreting the thermal histories of carbonate minerals, the mechanism of dolomitization, and other diffusion-controlled processes. The results indicate that cation diffusion in calcite is relatively slow and cations are the rate-limiting diffusing species for the deformation of calcite and carbonate rocks. Application of the calcite-dolomite geothermometer to metamorphic assemblages will be constrained by cation diffusion and cooling rates. The direct measurement of Mg tracer diffusion in calcite indicates that dolomitization is unlikely to be accomplished by Mg diffusion in the solid state but by a recrystallization process.



Significance: This work provides the first low-temperature determination of the diffusion rate of major cations in calcite. The accurate measurement of the diffusion coefficients is based on the use of isotope-enriched thin films that had been previously developed in our analysis of diffusion rates for silicate minerals. The kinetic data are useful in evaluating the suitability of carbonate mineral geothermometry, understanding dolomitization processes, and the preservation of chemical zoning associated with the Allan Hills meteorite.

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